RECENT CHANGES IN CULTIVATED LANDS WITHIN THE PRONGHORN ANTELOPE RANGE

by

Richard W. Haag
Resource Evaluation and Analysis

1986
Edmonton

Alberta Forestry, Lands and Wildlife
Resource Evaluation and Planning Division

87-00476/

Pub. No.: T/108
International Standard Book Number: 0-86499-304-8

FOR ADDITIONAL COPIES OF THIS REPORT, CONTACT:

Information Centre
Alberta Forestry, Lands and Wildlife
Main Floor, Bramalea Building
9920 - 108 Street
Edmonton, Alberta, Canada T5K 2M4

Telephone: (403) 427-3590

EXECUTIVE SUMMARY

In the early 1970s, personnel at the Regional Fish and Wildlife office in Lethbridge produced a map of cultivated lands in the pronghorn antelope range from interpretation of black and white aerial photography. Visual interpretation of Landsat imagery was used to update this map and assess recent changes in cultivation patterns.

Cultivated lands in the pronghorn range increased from 3 877 105 acres on the baseline map (29.7% of the pronghorn range) to 4 648 068 acres on the updated map (35.6% of the pronghorn range), an increase of 19.9% in the amount of cultivated land. Large tracts of "new" cultivated lands were found mainly in the northern part of the antelope range, while reversions from cultivation to some other use were scattered throughout the range.

Relative to the antelope winter ranges, the largest amounts of "new" cultivated land were found in the Lake Newell and Murray Lake ranges. Four winter ranges had small amounts of "new" cultivated land, and no "new" cultivated land was observed in six winter ranges.

Maps produced as part of the Agricultural Land Base Study were used to project the influence of current land use trends on future availability of antelope habitat. Substantial parcels of land suitable for rangeland conversion are found in the Milk River Ridge, Milk River and Lodge Creek winter ranges. The remaining winter ranges contain only small parcels of such land.

Substantial parcels of land suitable for irrigation expansion are found in the South Saskatchewan, Red Deer Valley and Grand Forks winter ranges. Past expansion of irrigation accounts for recent increases in cultivated lands within the Lake Newell and Murray Lake winter ranges.

Data on recent land use changes combined with assessments of the potential for agricultural expansion in the future provide a basis for the development of strategies to achieve management objectives for the provincial pronghorn population.

TABLE OF CONTENTS

		Page
1.	INTRODUCTION	1
2.	STUDY AREA	3
3.	HISTORICAL TRENDS	7
	3.1 Agricultural Land Use	7
	3.2 Pronghorn Antelope Numbers	12
4.	METHODS	15
	4.1 Baseline Data	15
	4.2 Landsat Imagery	15
	4.3 Interpretive Criteria	18
	4.4 Map Production and Analysis	23
	4.5 Limitations to the Interpretation	25
	4.6 Field Check	26
5.	RESULTS AND DISCUSSION	29
	5.1 Field Check	29
	5.2 Regional Patterns	31
	5.3 Relationship to Winter Habitat	34
	5.4 Protection of Land Use Trends	37
REFERENCES		41

LIST OF ILLUSTRATIONS

Figure		Page
1	Wildlife Habitat Regions of Alberta	4
2	Areas of Total and Improved Farmland in Alberta, 1921-1976	9
3	Estimated Antelope Numbers in Alberta, 1900-1974	13
4	Summer Landsat Imagery From an Area Northeast of Murray Lake Showing a Wide Variety of Land Covers	17
5	Fall Landsat Imagery From the Same Area Northeast of Murray Lake that Appears in Figure 4, Showing a Variety of Land Covers	20
6	Crop Calendar for the Southern Region of Alberta	22
7	Antelope Winter Ranges and the Distribution of Land with the Potential for Range Conversion	35
8	Antelope Winter Ranges and the Distribution of Land with Potential for Irrigation Expansion	36

LIST OF TABLES

Table		Page
1	Land Use Change Data for Census Districts in the Southern Region, 1961-1976	10
2	Spectral Sensitivity and Color Conventions on LANDSAT-4 Color Imagery	16
3	Color Signatures of Land Cover Types on 31 July LANDSAT-4 Imagery	21
4	Color Signatures of Land Cover Types on Late September-Early October LANDSAT-4 Imagery	24
5	Confusion Matrix for Field Check of Updated Cultivated Land Maps	31
6	Summary of Cultivation Changes in Wildlife Management Units in the Pronghorn Range	33

PREFACE

In July, 1984 the Resource Appraisal Section of Resource Evaluation and Planning was requested by the regional office of Fish and Wildlife in Lethbridge to produce a map of cultivated lands within the pronghorn antelope range and to analyse changes in cultivation patterns by comparison with a map produced in the early 1970s. This project was undertaken with the co-operation of individuals from a number of government agencies.

Discussions with Lorne Russell, head of Regional Wildlife Services, Lorne Fitch, head of Regional Habitat Services and Harry Vriend, habitat development biologist from the regional office in Lethbridge, were critical in identifying project objectives. Jim Clark, habitat development biologist, served as the contact person and provided excellent criticism of mapping methods and data presentation.

Ian Sutherland from the Alberta Remote Sensing Centre of Alberta Environment provided valuable advice on selection of Landsat imagery and methods of interpretation. He also provided access to imagery on file at the Centre which proved valuable in resolving a number of interpretive questions.

Robin Boodle, a P.E.P. employee with the Resource Appraisal Section, conducted the preliminary interpretation of Landsat imagery.

Lloyd Marshall and Bob Anderson from Cartographic Services, Resource Evaluation and Planning, provided assistance with finalization of the maps and text figures.

Planimetry was performed under contract to PPL Computer Graphics Ltd. Bruce Mackenzie, manager of Photogrammetric Services, made arrangements for the contract and Adolph Tonn acted as contract co-ordinator.

1. INTRODUCTION

The recent report Status of the Fish and Wildlife Resource in Alberta (Alberta Energy and Natural Resources, Fish and Wildlife Division 1984) identified goals for the management of the provincial pronghorn antelope population. The goal of population management is to maintain numbers between 10 000 and 18 000 animals. Since this target represents the carrying capacity of the present range, its achievement depends on the maintenance and possible enhancement of about 15 000 km^2 of yearround habitat and about 3 037 km^2 of winter habitat.

During the 1970s, staff at the Regional Fish and Wildlife office in Lethbridge produced a map showing the distribution of cultivated lands within the range of pronghorn antelope in Alberta. This map was used indirectly to assess the availability and distribution of potential antelope habitat, and to assist in decision making regarding disposition of Crown land for agricultural purposes.

In 1984, the regional office in Lethbridge requested the production of an updated version of this map. The purposes of the update were to:

1) identify recent changes in agricultural land use within the pronghorn antelope range, and

2) assist in making land allocation decisions in relation to provincial targets for pronghorn antelope numbers.

The updated map was produced by the Resource Evaluation and Planning Division from visual interpretation of 1983 Landsat imagery. This report presents the results of that interpretation with background information to make the map more useful.

2. STUDY AREA

The range of the pronghorn antelope corresponds closely to the shortgrass prairie region of Alberta, with small portions in the mixedwood prairie (Fig. 1). The climate in this portion of the province is semi-arid and periodic summer drought has a major ecological influence. The native prairie vegetation is dominated by drought-resistant grasses including speargrass, junegrass and blue grama grass, along with a variety of broadleaved plants such as pasture sagewort, moss phlox, little clubmoss and prickly pear cactus. Woody plants are generally restricted in their occurrence. Rose, snowberry, chokecherry, silverberry and aspen are found in coulees and on sand hills. Cottonwood, balsam poplar and willows are generally confined to river valleys. Silver sage, of special importance as a major food for antelope (Mitchell and Smoliak 1971), is found throughout the area but generally reaches highest cover values in low-lying basins where there are fine-textured soils.

The modal soils in the prairies are Brown (in the shortgrass prairie) and Dark Brown (in the mixedgrass prairie) Chernozems. These soils have a deep humus layer due to the annual decomposition of root matter, and they are only slightly leached because of low rainfall. Saline soils of the Solonetzic order are common in areas of groundwater discharge.

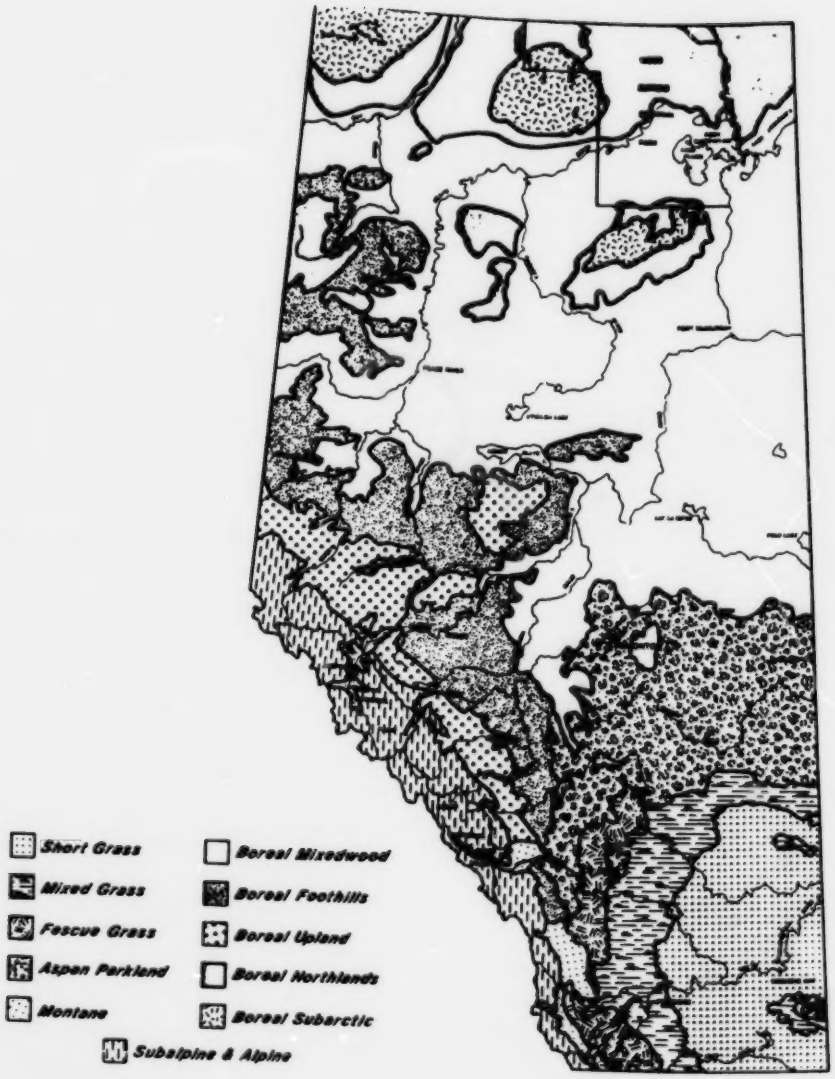

Fig. 1. WILDLIFE HABITAT REGIONS OF ALBERTA. Source: Pedocan Land Evaluations 1984, adapted from Strong and Leggat 1981).

This landscape supports an abundant and diverse wildlife including species like mule deer that are found throughout the province and others like antelope and sage grouse that are unique to the prairies.

3. HISTORICAL TRENDS

3.1 Agricultural Land Use

Small scale conversion of wild land to agricultural use began in the last part of the 18th century as trading outposts were established in Alberta. MacGregor (1977) notes that as early as 1787 Peter Pond was growing a garden along the lower Athabasca River, and that barley crops were grown at Fort Edmonton as early as 1810. These early efforts were designed to meet local needs, and it was not until passage of the first Dominions Lands Act (1872) which granted free homesteads to settlers and the construction of the Canadian Pacific Railway (1881-1885) that conversion to agricultural use began in earnest.

Systematic records of agricultural land use in Alberta are available from the agricultural census beginning in 1921 (McCuaig and Manning 1982). Census data identifies two types of farmland. Improved farmland includes cropland, improved pasture, summer fallow and other related land (farmyards, roads and trails, idle land). Unimproved farmland includes woodland, wetlands and native pasture which are lands that are used in their natural state. These records show that the total amount of farmland in the province rose from 29 281 600 acres in 1921 to 49 909 249 acres in 1976 (Fig. 2A). The rate of addition of new farmland (which averaged 1.28% per year) generally decreased over time with the greatest decrease occurring around the Second World War. Improved farmland increased from 11 763 441 acres in 1921 to 29 290 734

acres in 1976, for an average annual increase of 2.71%. The rate of addition of improved farmland did not show the same tendency to decrease during later census intervals (Fig. 2B), indicating that intensification of use has been a major trend in recent times.

McCuaig and Manning (1982) presented a separate analysis of land use changes by standardized census district that permits a closer look at the situation in the southern region of the province (Table 1). The amount of improved and unimproved farmland in Census Districts 901-906 decreased by 298 996 acres from 1962 to 1976. The Medicine Hat and Taber-Lethbridge districts showed an increase in total farmland, while total farmland in the other four districts decreased. The amount of improved farmland increased in all census distdricts over the same period, for an increase of 741 469 acres in the southern region.

Birch (1982) recently conducted a study of further changes in the agricultural land base from 1976 to 1980 and concluded that there had been virtually no change in the amount of land in agricultural use during this period. Based on a detailed analysis of data on the disposition and use of Crown lands from Alberta Energy and Natural Resources and other data on land use changes from Alberta Municipal Affairs and the Energy Resources Conservation Board, he found that Alberta's agricultural land base had decreased by an average of about one section per year from 1976 to 1980. This small net change was underlain by substantial changes in land allocation and land quality. An average of 77 000 acres had been added and 78 000 acres removed from the land base each year, and the CLI rating of land that was added was

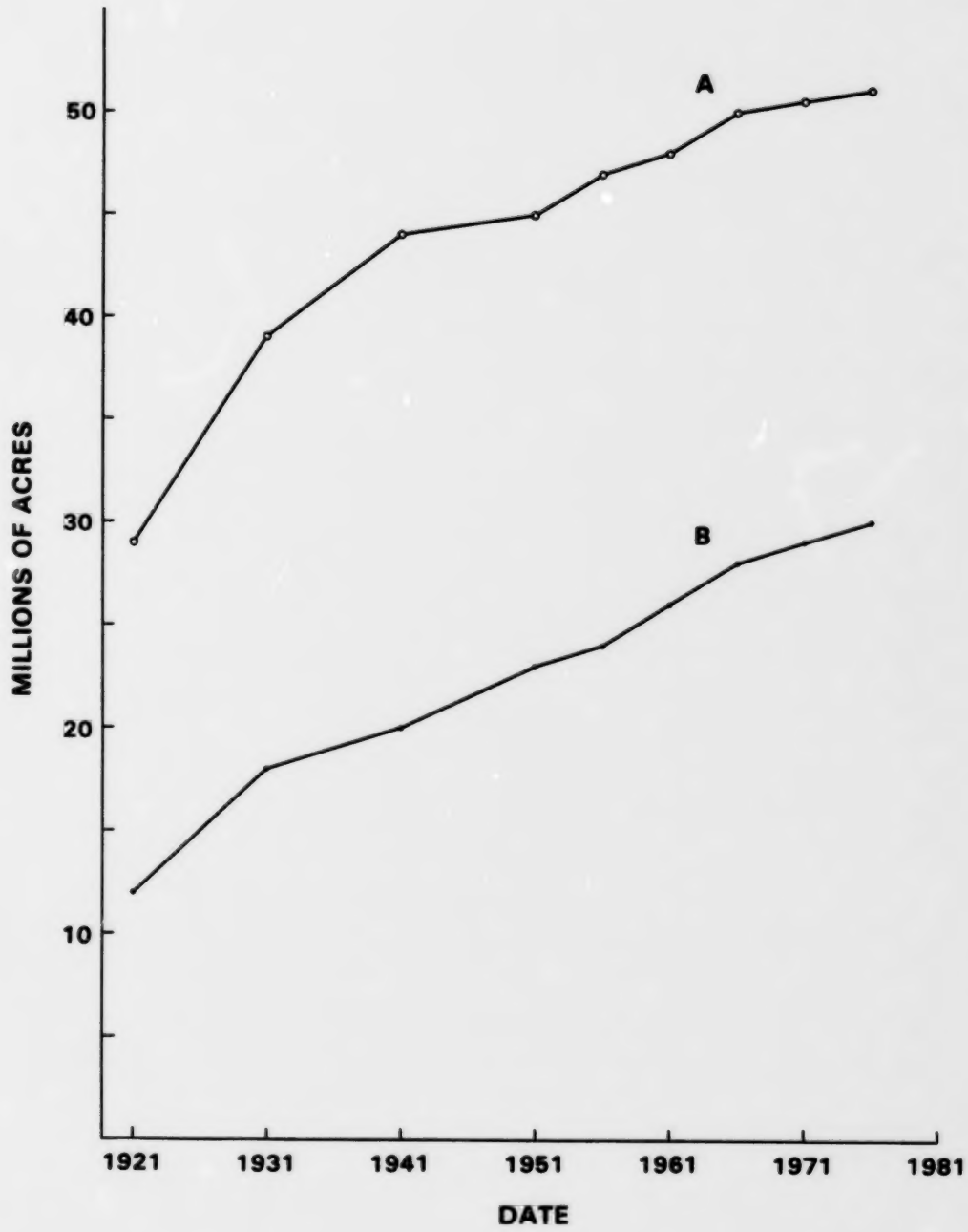

Fig. 2. AREAS OF TOTAL (A) AND IMPROVED (B) FARMLAND IN ALBERTA. 1921-1976. Source: McCuaig and Manning 1982.

Table 1

LAND USE CHANGE DATA FOR CENSUS DISTRICTS
IN THE SOUTHERN REGION, 1961-1976

Census District	Change in Total Farmland (ac)	Change in Improved Farmland (ac)
Medicine Hat	+ 74 298	+ 92 084
Taber-Lethbridge	+ 296 889	+ 193 164
Fort McLeod	- 282 133	+ 96 755
Red Deer Valley	- 133 387	+ 232 659
Drumheller	- 45 781	+ 92 320
Calgary	- 208 880	+ 29 487
TOTAL	- 298 996	+ 741 469

Source: McCuaig and Manning 1982

lower than that of the land that had been removed from agricultural use.

In the southern region of the province, which includes the pronghorn antelope range, the amount of land used for agriculture decreased by an average 4 525 acres per year, for an estimated total reduction of 22 626 acres over the five year period (from Table 6, 5.8% of a total provincial decrease of 390 100 bacres). The most common reasons for removal of land from agricultural use were urban annexations, non-agricultural subdivisions, and road construction and widening.

A recent report by the Environment Council of Alberta (1984) suggests that this pattern of reversion to non-agricultural use may be a temporary phenomenon. In recent years agricultural land close to urban centres has acquired considerable speculative value because of the responsibility that the land could be used for some purpose other than agriculture. This inflation of value, which provided an incentive for conversion from agricultural to non-agricultural use, was in large part the result of the rapid influx of people to the province during the boom years of the late 1970s. It is unlikely that this pattern will persist in the face of stabilization of the provincial economy.

Recent studies of the agricultural land base indicate that there is still considerable potential for intensification and expansion of agriculture in the southern region of the province (Agricultural Land Base Study Progress Report, April 25, 1984). Some types of

agricultural expansion would have little effect on the availability of potential antelope habitat; reduction in allow acreage, for example. Other means of increasing agricultural production could have a significant effect. The two most significant are conversion of rangeland and expansion of irrigation. Possible impacts of these activities are assessed at the end of this report.

3.2 Pronghorn Antelope Numbers

Mitchell (1980) cites estimates that before European settlement in North America, pronghorn numbers equalled or exceeded those of the bison (30 to 40 million; Nelson 1925, Seton 1953). The number of pronghorns declined rapidly as settlement occurred as a result of habitat conversion, competition with cattle, weather, predation, disease and hunting. The animals remained numerous, however, at the beginning of the 20th century.

Mitchell (1980) has reconstructed pronghorn population trends from 1900-1974 using data from a variety of sources. His reconstruction should be treated as an approximation, since the quality of population records varies widely. The time of year when estimates were made and the intensity of population surveys are not specified, for example. According to the estimates he used, population size has fluctuated from less than 2 000 to nearly 22 000 animals (Fig. 3). His interpretation indicates that of all the factors that influence population size, winter weather has the greatest influence on the number of antelope in the province. Severe winters have caused major reductions in population size and have prevented small populations

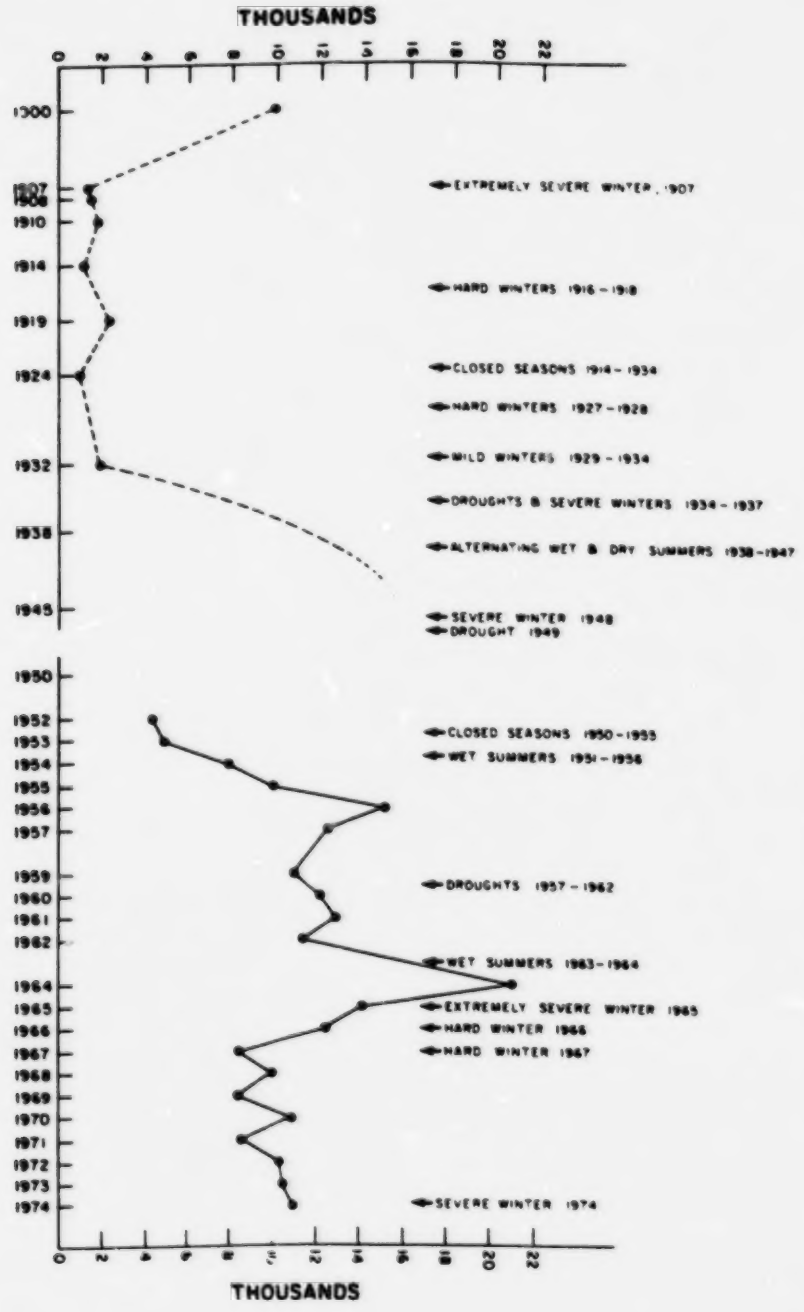

Fig. 3. ESTIMATED ANTELOPE NUMBERS IN ALBERTA, 1900-1974.
Source: Mitchell 1980.

from expanding even after closure of the hunting season. The influence of severe winters has been documented by others; Barrett (1982) reported 48.5% mortality in a total population of approximatley 14 360 animals during the severe winter of 1977/78.

Severe winter weather has also caused shifts in distribution that reflect a species at the limits of its geographic range. These shifts may occur locally; Barrett (1982) fould that about two-thirds of the provincial population was displaced from the low-lying brushlands that are normal winter range into areas with lower snow cover during a severe winter. On a broader scale, Anderson (1924) indicated that the severe winter of 1906/07 displaced pronghorns from much of their Canadian range and that large portions of the range remained unoccupied in the fall of 1907. An extensive survey by Nelson (1925) indicated that during the general decline in antelope numbers during the early part of the century, the species had been eliminated from large portions of its former range in the east.

4. METHODS

4.1 Baseline Data

The original cultivated lands map produced in about 1970 by regional Fish and Wildlife personnel was the source of baseline information. This map was produced at a sale of 1:250 000 from black and white air photos obtained at several scales during the late 1960s and early 1970s. We were not able to obtain a record of the photos that were used to produce the map, so we treated it as a somewhat fluid picture of the pattern of agricultural land use 15 to 20 years in the past, appropriate for interpretation of regional trends over the medium and long term.

4.2 LANDSAT Imagery

The updated map of cultivated lands was produced by visual interpretation of LANDSAT-4 imagery. We chose Landsat imagery for 3 reasons:

1. Availability of prints at the same scale as the baseline map so land use changes could be determined by direct overlay.

2. Availability of coverage within a 12 month period for 95% of the area.

3. Lower costs compared to black and white photos for complete coverage of the area.

The pronghorn antelope range occurs on parts of eight LANDSAT-4 scenes. The requirement for low (<5%) cloud cover necessitated selection of scenes from three different dates. Small cloud-covered areas were mapped by interpretation of black and white air photos.

The LANDSAT-4 prints that we analysed were false-color composites of bands 1, 2 and 4. The spectral sensitivity of these bands is shown in Table 2. The general appearance of these Landsat prints is normally quite similar to conventional false-color air photos. However, the color balance of the prints we analysed was shifted strongly toward the green wavelengths (Fig. 4) because of drift in the output from one of the four sensors that was not corrected until our imagery had been processed.

Table 2

SPECTRAL SENSITIVITY AND COLOR CONVENTIONS
ON LANDSAT-4 COLOR IMAGERY

Band	Wavelengths	Objects Detected	Color on Image
1	500- 600 nm	Vegetation, water	Blue
2	600-700 nm	Bare soil, mature and senescent vegetation	Green
3	700- 800 nm		Not printed
4	800-1100 nm	Healthy vegetation	Red

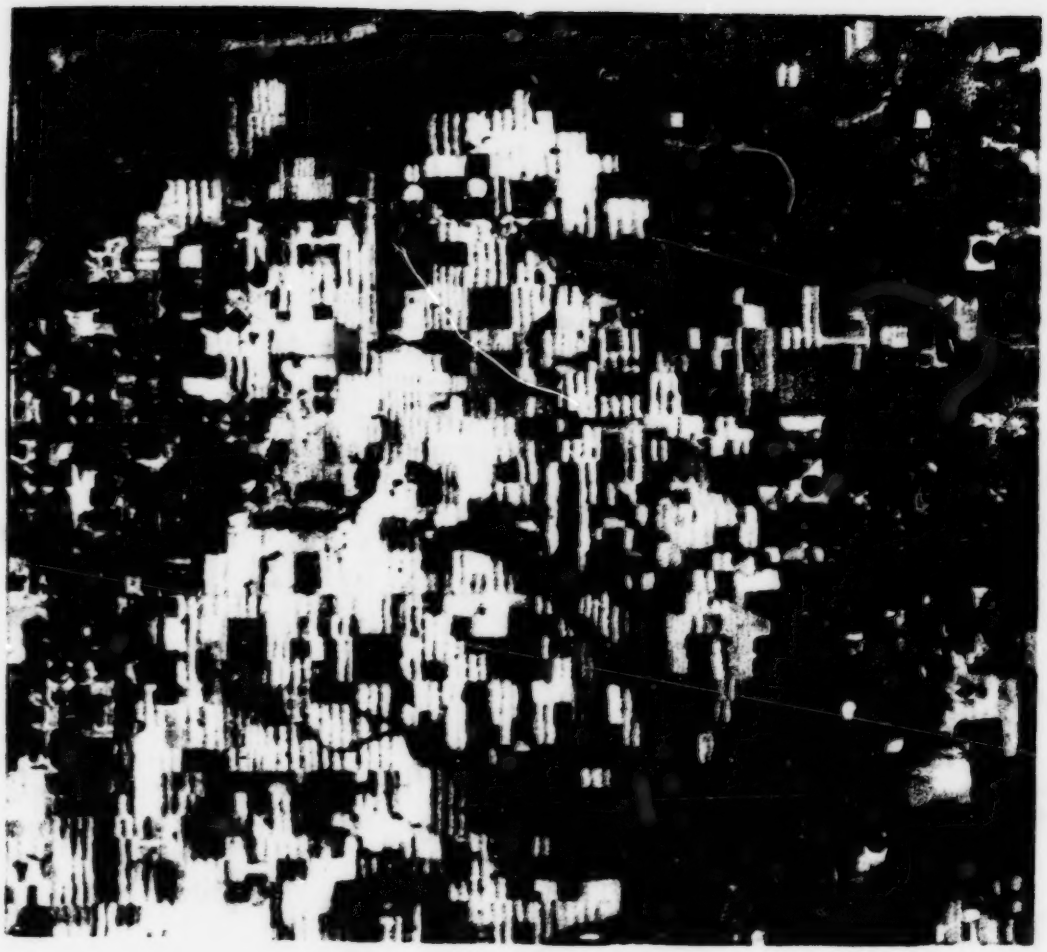

Fig. 4. SUMMER LANDSAT IMAGERY FROM AN AREA NORTHEAST OF MURRAY LAKE SHOWING A WIDE VARIETY OF LAND COVERS.

1. Irrigated cropland.

2. Strip-cropping with mature crops (white-yellow), actively growing crops (orange-red) and fallow land (light-medium green).

3. Native vegetation in the Murray Lake winter range (grassland - medium green, riparian vegetation and shrubland - olive-red).

4. Sparsely vegetated southern exposure in the South Saskatchewan river valley (pale blue).

5. Grazed pasture in the Bow Island Grazing Reserve (light-medium green).

4.3 Interpretive Criteria

Landsat imagery provides a record of the average reflectance of the ground surface that can be used to identify land cover. A map of cultivated lands is a record of land use rather than land cover; however, since cultivation is a process that can be used to manufacture a variety of land covers. Land covers produced by cultivation include the following: annual cereal crops produced by dryland farming methods, annual cereal and other crops (e.g. sugar beets) produced under irrigation, perennial forage crops grown for hay, and fallow land, which may or may not have a cover of weeds. The appearance of each of these cover types varies widely over the course of the year. The interpretation of land use requires an ability to recognize each of these cover types and to distinguish them from other types that are not the result of cultivation.

Reliable and consistent interpretation depends on the identification of suitable criteria and sequential application to narrow down the range of possibilities and arrive at an accurate classification. The following criteria were applied in sequence to identify cultivated lands (Plitz 1982, Pearce et al. 1983).

1. Shape. Cultural features including parcels of agricultural land are usually regular in shape, while natural objects have an irregular shape. The first step in the interpretation is to identify all regularly-shaped land parcels.

Circular features up to one section in size are classified as cultivated land under pivot irrigation.

Rectilinear parcels are interpreted as either cultivated or grazing land.

Irregularly shaped parcels are interpreted as "wild land" (including native rangeland used for grazing) and are not examined further.

2. Pattern. This criterion gives important clues to the use of the land in question.

   Regular parcels divided into alternating light and dark strips, and generally oriented N-S, are interpreted as cultivated land under fallow rotation in a pattern typical of dryland farming (Figs. 4 and 5). The color pattern of these parcels varies widely among seasons. Contiguous small parcels with a range in colour and tone similar to that in strip-cultivated areas are also interpreted as cultivated land in fallow rotation.

   Remaining regular features include both cultivated and grazing land.

3. Color and texture. These criteria are used to check interpretations from previous steps and to isolate grazing land further. The interpretation of image colors is made complex by the number of possible land covers produced by cultivation, and because the appearance of these covers

Fig. 5. FALL LANDSAT IMAGERY FROM THE SAME AREA NORTHEAST OF MURRAY LAKE THAT APPEARS IN FIG. 4, SHOWING A VARIETY OF LAND COVERS

1. Mature (yellow) and harvested (light-medium green) irrigated crops.

2. Harvested dry land crops showing stubble (pale blue-green) and fallow fields (light-medium green).

3. Native vegetation in the Murray Lake winter range (shrubs have lost their leaves and no longer appear red).

4, 5. Areas of native grassland appear darker than on summer imagery because sunlight is less intense.

varies from season to season. A crop calendar presented by Reichert and Crown (1984) was used to aid in the interpretation of colour (Fig. 6).

On late July imagery, land covers produced by cultivation include actively growing crops planted in spring, mature crops planted in spring and fall, stubble remaining after harvest of fall planted crops, and fallow land. The color signatures of these land covers are presented in Table 3.

Table 3

COLOR SIGNATURES OF LAND COVER TYPES
ON 31 JULY LANDSAT-4 IMAGERY

COVER TYPE	COLOR ON IMAGE
Actively growing dryland crops	Pale blue, red
Actively growing irrigated crops	Red
Mature crops	White, yellow
Stubble fields	Light to medium green
Fallow land	Pale to light green
Native rangeland	Light blue to medium/ dark green
Improved pasture	Dark green

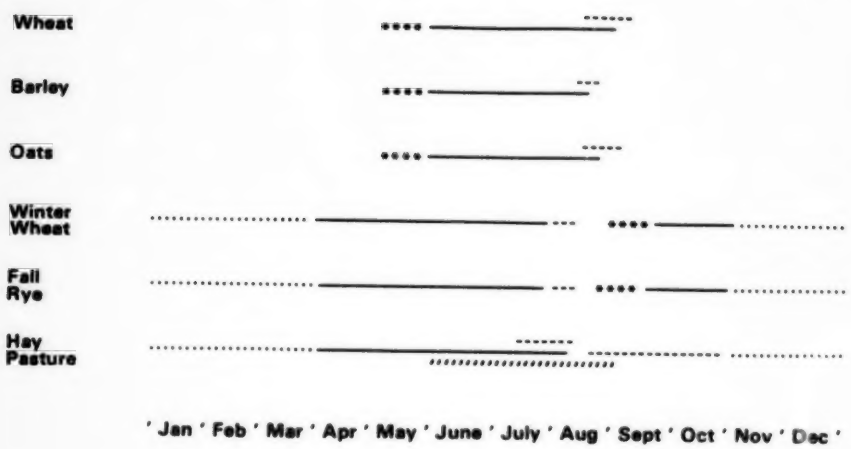

FIG. 6. CROP CALENDAR FOR THE SOUTHERN REGION OF ALBERTA.
Source: Reichert and Crown 1984.

On summer imagery, there was a pattern of earlier crop maturity in the south, with white and yellow parcels more common than in the north. In the northern part of the area, fields supporting crops still appeared red indicating that these crops had not matured.

There was an overlap of colors among parcels interpreted as fallow and/or stubble land and parcels interpreted as rangeland used for grazing. Where there was uncertainty, the conservative approach classified the parcel as cultivated land.

On fall imagery, land covers produced by cultivation included mature grain crops seeded in spring, stubble remaining after harvest, actively growing crops seeded in fall, mature hay crops and fallow land (Fig. 6). The color signatures of these land cover types were different from those seen in July because of the lower input of sunlight later in the year (Table 4, Fig. 5).

Again, there was considerable overlap of colors between cultivated land and other land covers, especially in the medium green tones. Again, the conservative approach was taken and uncertain parcels were classified as cultivated.

4.4 Map Production and Analysis

The location of all parcels classified as cultivated land was outlined directly on the images and transferred to mylar transparencies of 1:250 000 scale NTS sheets by direct overlay. The map of 1983 cultivated lands was then overlaid on the original cultivated lands map in order to identify currently uncultivated parcels that were

cultivated on the original map along with "new" cultivated lands. The updated map thus identified four classes of land:

- cultivated on the original map but not cultivated at present.
- not cultivated on the original map but cultivated at present.
- cultivated on both maps
- not cultivated on either map.

The final step in the analysis was to add the boundaries of Wildlife Management Units (WMUs) and to determine the proportion of land in each class within each WMU using an electronic planimeter. WMU boundaries do not appear on the maps that accompany this report, because they are likely to change from time to time and they gave the map a very cluttered appearance.

Table 4

COLOR SIGNATURES OF LAND COVER TYPES ON LATE SEPTEMBER-EARLY OCTOBER LANDSAT-4 IMAGERY

COVER TYPE	COLOR ON IMAGE
Actively growing crops	Pale to medium blue-green
Mature grain crops	Pale green, yellow, white
Mature hay crops	Medium-dark green, red
Stubble fields	Light to medium green
Fallow land	Light to medium green
Native rangeland	Medium to dark green
Improved pasture	Very dark green

4.5 Limitations to the Interpretation

1. The color interpretation key devised for this project should not be used with other Landsat imagery because of the overrepresentation of green tones due to drift in one of the MSS sensors. Interpretations based on this key were checked against earlier Landsat imagery with better color balance (courtesy of Ian Sunderland at the Alberta Remote Sensing Centre), and we are confident in the interpretation. However, attempts to use our color keys to interpret properly balanced imagery would probably be very frustrating and lead to incorrect results.

2. We did not treat urban or industrial land as a separate class. We "mapped around" larger urban centres (e.g. Medicine Hat, Taber). We included smaller towns in with cultivated lands because they usually abutted cropland and the parcels they occupied were small in a regional context.

3. Land use changes relating to road construction and widening and well site access and construction do not appear on the map. While changes in land cover due to these activities may be significant (Birch 1982), the parcels involved are smaller than the practical resolution limits of Landsat imagery.

4. In general, the smallest parcel of land that we mapped was one quarter-section in size. However, where there were large number of small contiguous parcels and most of them were cultivated, we did not attempt to isolate all the non-cultivated ones. Our rationale was based on Barrett's (1980) observation that preferred antelope ranges contain an average of 88% native vegetation. We did not feel that inclusion of small parcels of native vegetation in the cultivated land base within heavily farmed areas detracted from the usefulness of the map.

5. The location accuracy on Landsat composite prints is generally regarded as about 700 m. Location accuracy for most parcels, especially in heavily developed areas, is probably greater than this. However, spatial accuracy will be lower for relatively isolated small parcels of cultivated land.

4.6 Field Check

The accuracy of updated cultivated lands maps was checked in the field by recording land cover by quarter section while travelling in a vehicle along a preselected route. The route was selected by users of the map to include areas where substantial changes in land use had been mapped. Side loops around the town of Schuler (Twp. 15-16, R. 1), north of Jenner (Twp. 21-22, R. 8-9), east of Tide Lake (Twp. 19, R. 9-10) and north of Patricia (Twp. 20, R. 12-13) were included to allow examination of large blocks of "new" cultivated land.

Observations were recorded on 1 138 quarter sections of land. Land parcels were classified into four land cover types: annual cropland (including fallow), perennial (forage) cropland, native vegetation, and improved pasture planted to tame grasses. The class improved pasture was treated separately so that we could determine the land use class in which it tended to fall.

5. RESULTS AND DISCUSSION

5.1 Field Check

The updated cultivated lands maps provide information on both current land cover and land use change. The accuracy of current land cover mapping was fairly high; 92.6% of the lands mapped as currently cultivated (map classes "cultivated on baseline map and 1983 update" and "not cultivated on baseline map, cultivated on 1983 update") consisted of annual or perennial cropland. Currently uncultivated lands were mapped with slightly lower accuracy; 90.5% of the lands mapped as currently uncultivated (map classes "native vegetation, not cultivated on either date" and "cultivated on baseline map, not cultivated on 1983 update" consisted of rangeland or improved pasture.

The accuracy of land use change detection cannot be assessed directly from the field check because no estimate is available of the accuracy of the baseline map. Each land use class on the maps can be assessed for consistency with current land cover classification, however, (Table 5).

The land use class "cultivated on baseline map and 1983 update" was highly consistent with observations of current land cover; 95% of the parcels so mapped consisted of annual or perennial cropland. A similar result was observed for the class "not cultivated on baseline

map, cultivated on 1983 update"; 90% of these land parcels consisted of annual or perennial cropland.

Neither of the other two land use classes should have contained cropland. The class "native vegetation, not cultivated on either date" was highly consistent with land cover mapping; 93% of these parcels had a cover of native vegetation. The class "cultivated on baseline map, not cultivated on 1983 update" did not fare so well; however, only 33% of these parcels consisted of native vegetation.

The results of the field check suggest that there were two major sources of error in land cover interpretations. The first lies in the use of less than optimal image dates. We found interpretations based on imagery from late July to be the most accurate, because of the high contrast among spectral signatures of the land covers of interest. Accuracy was lower with images from early April and late September, because of lower contrast among spectral signatures and generally lower levels of illumination.

The second source of error is the use of single data imagery. Even with the use of imagery from the optimal late summer period, there is the possibility of confusing several cover types. For example, heavily grazed rangeland or pasture can be mistaken for fallow fields that have not yet been disked. In such cases, comparison with spring imagery would permit a more accurate interpretation. The use of multi-date imagery might also improve the accuracy with which improved pasture was identified.

Table 5

CONFUSION MATRIX FOR FIELD CHECK OF UPDATED CULTIVATED LAND MAPS

Map Class	Land Cover Classes: Annual Crop	Hay Crop	Range-land	Improved Pasture	% Correct
Cult. 1970 and 1983	475	20	20	6	95
Cult. 1983 not 1970	85	15	5	6	90
Cult. 1970 not 1983	19	12	12	3	33
Not Cult.	15	2	428	15	93

5.2 Regional Patterns

There has been a substantial increase in the amount of cultivated land in the pronghorn antelope range since the baseline map as produced. On the baseline map 3 877 105 acres (29.7% of the land in the pronghorn range) was under cultivation. In 1983, an estimated 4 648 068 acres of land (35.6% of the pronghorn range) was cultivated. The amount of cultivated land thus increased by 770 964 acres during the interval between production of the two maps, an increase of 19.9%. This net increase represents the balance between 1 076 512 acres of "new" cultivated land and 305 549 acres of land that reverted from cultivation to some other use.

The largest contiguous blocks of "new" cultivated land were found in the following areas: south of Schuler (Twp. 14-15, R.1), southwest of Dinosaur Provincial Park (Twp. 20, Rg. 12-13), north of Bow City (Twp. 17-18, Rg. 16-17), northeast of Sibbald (Twp. 28, R. 1), east of Dinosaur Provincial Park along the Red Deer River (Twp. 22, R. 8, 10) and south-southeast of Sullivan Lake (Twp. 31-33, R. 14).

There were very few large parcels of land that had reverted from cultivation to some other use. The greatest concentrations of land that had reverted from cultivation were found in the following areas: south of Cypress Hills Provincial Park (Twp. 7, R. 1-3), east of Dinosaur Provincial Park along the Red Deer River (Twp. 22-23, R. 7-9) and south of the North Milk River (Twp. 1-2, R. 20-23).

The antelope range consists of all or parts of 24 wildlife management units, in addition to Cypress Hills Provincial Park (WMU 120) and Suffield Military Reserve (WMU 146). Land use changes in ech WMU are summarized in Table 6.

There was a net decrease in the amount of cultivated land in the three WMUs that abut the Saskatchewan border south of the Trans-Canada highway. The amount of cultivated land increased in the other 21 wildlife management units.

Net increases in cultivated lands exceeded 75 000 acres in four WMUs north of the Trans-Canada highway: 162, 164, 152 and 151. Increases in cultivated lands from 25 000 to 75 000 acres were recorded in WMUs 142, 148, 166, 144 and 138. In the remaining 12 WMUs, the amount of cultivated land increased by less than 25 000 acres.

Table 6

SUMMARY OF CULTIVATION CHANGES IN WILDLIFE MANAGEMENT UNITS IN THE PRONGHORN RANGE

(All areas are given in acres and percentages are shown in parentheses)

WMU	Total Area	Cultivated 1970	Cultivated 1983	Net Change
102	842 018	77 229 (9.6)	73 552 (8.7)	- 3 677
104	251 577	122 166 (48.6)	126 699 (50.40	+ 4 533
106	701 658	559 013 (79.7)	573 845 (81.8)	+ 14 832
108	515 119	144 564 (28.1)	144 799 (28.1)	+ 234
112	690 572	571 738 (82.8)	590 663 (85.5)	+ 18 925
116	502 680	229 582 (45.7)	236 060 (47.0)	+ 6 478
118	426 628	30 203 (7.1)	16 090 (3.8)	- 14 113
119	319 942	129 734 (40.5)	124 320 (38.9)	- 5 413
120	47 592	1 279 (2.7)	------- ------	- 1 279
124	363 107	142 489 (39.2)	15 859 (42.9)	+ 13 370
128	462 391	161 182 (34.9)	179 786 (38.9)	+ 18 604
130	53 122	21 086 (39.7)	23 485 (44.2)	+ 2 399
134	2 880	1 919 (66.6)	2 880 (100)	+ 961
138	360 173	86 840 (24.1)	122 221 (33.9)	+ 35 381
140	338 802	198 474 (58.6)	221 374 (65.3)	+ 22 900
142	358 975	70 230 (19.6)	127 272 (35.5)	+ 57 042
144	609 048	74 594 (12.2)	112 185 (18.4)	+ 37 591
146	655 130	------- ------	------- -----	--------
148	705 916	159 157 (22.5)	211 585 (30.0)	+ 52 428
150	474 746	133 474 (28.1)	143 070 (30.1)	+ 9 596
151	697 192	256 798 (36.8)	332 573 (47.7)	+ 75 775
152	821 776	112 341 (13.9)	189 723 (23.1)	+ 77 382
160	344 921	32 066 (9.3)	65 393 (19.0)	+ 33 327
162	1 182 068	260 402 (22.0)	425 917 (36.0)	+165 515
164	1 195 144	293 609 (24.6)	297 174 (33.2)	+103 565
166	125 103	6 933 (5.5)	51 544 (41.2)	+ 44 611

5.3 Relationship to Winter Habitat

Barrett and Vriend (1980) identified 12 known winter ranges of pronghorn antelope in Alberta. The location of these ranges is shown in Figs. 7 and 8. We examined these areas to identify recent trends in land use.

In the early 1970s relatively large amounts of cultivated land were found in three ranges: the northern portion of Murray Lake (approximately 80% cultivated), Lake Newell (approximately 50% cultivated) and Walsh Flats (approximately 25% cultivated). Six ranges contained on the order of 10% cultivated lands: Milk River Ridge, Red Deer River, Milk River (western portion), Canal Creek (eastern portion), Sage Creek and South Saskatchewan River. Less than 5% of the Milk River (eastern portion), Murray Lake (southern portion), Grand Forks, Lodge Creek and Suffield winter ranges were cultivated.

Inspection of the updated maps shows that in six of the 12 ranges there were no "new" cultivated lands. These ranges were: Sage Creek, Milk River, Canal Creek, Grand Forks, Suffield, and the southern portion of the Murray Lake range. Within the Sage Creek range, the amount of cultivated land appeared to have decreased by about three sections over the past 10 to 15 years. Reversions to non-cultivated use were smaller in the other ranges in this group.

Small amounts of "new" cultivated land were seen in four ranges: Milk River Ridge (4-5 sections), Red Deer River (4-5 sections), South Saskatchewan River (2-3 sections) and Walsh Flats (1-2 sections). Of

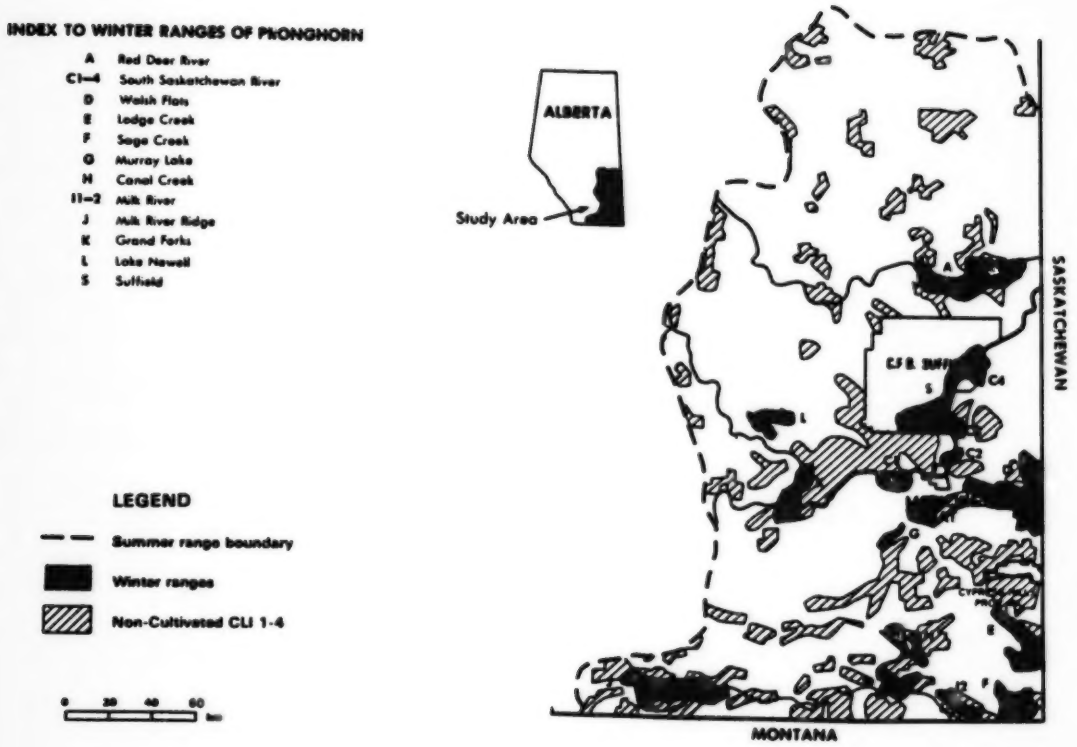

Fig. 7. ANTELOPE WINTER RANGES AND THE DISTRIBUTION OF LAND WITH THE POTENTIAL FOR RANGELAND CONVERSION (defined as currently uncultivated land in CLI Classes 1-4).

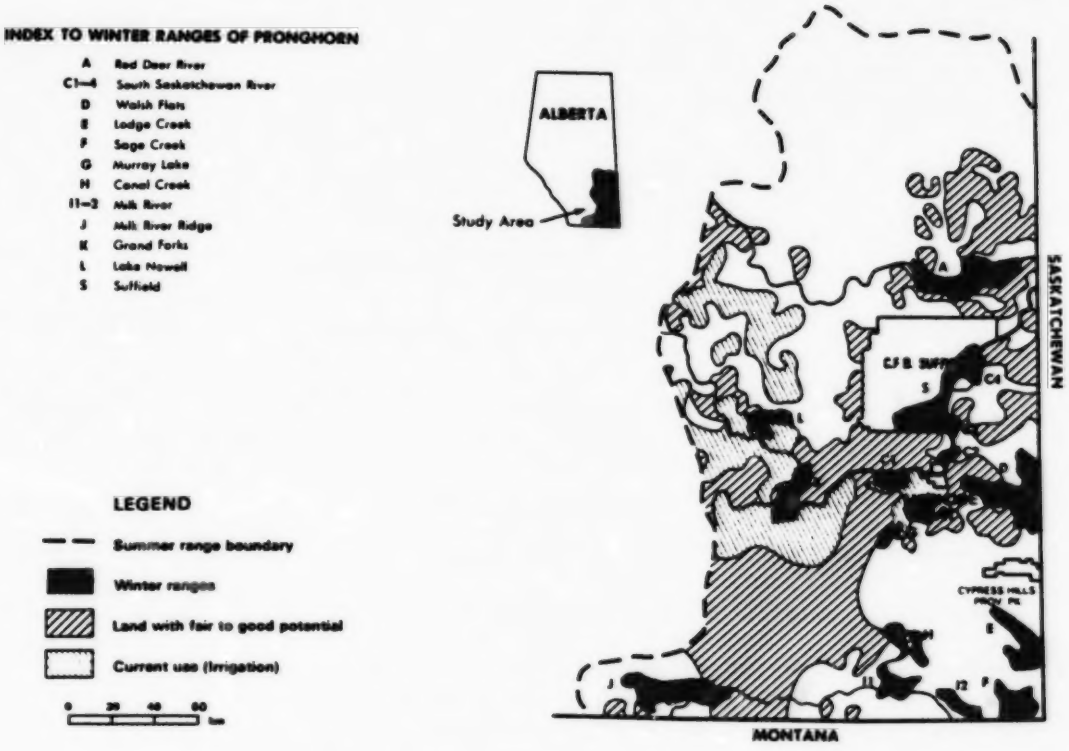

Fig. 8. ANTELOPE WINTER RANGES AND THE DISTRIBUTION OF LAND WITH POTENTIAL FOR IRRIGATION EXPANSION.

these areas, the greatest amount of reversion to non-cultivated use was in Walsh Flats (3-4 sections) and the South Saskatchewan River (1-2 sections).

More substantial amounts of "new" cultivated land relative to the size of the areas were found in the Lake Newell (10-11 sections) and Murray Lake (6-7 sections) ranges. Reversions to non-cultivated use accounted for less than one section in each of these areas.

5.4 Protection of Land Use Trends

The recent report Maintaining and Expanding the Agricultural Land Base in Alberta: Summary and Recommendations (Environment Council of Alberta 1984) identifies the major role of agriculture in the provincial economy and emphasizes the importance of sound land management to the future of agriculture in the province. The theme of several recommendations is that land allocation decisions need to be made with a view toward sustainability of agricultural use, and that there are many lands not suitable for farming.

Alberta's potential arable land base is currently defined as all lands rated as class 4 or better by the Canada Land Inventory. In the southern region of the province, lands in CLI classes 1-4 that are currently unfarmed have been identified as potentially arable through range conversion. A map of these lands, prepared by Alberta Agriculture through visual interpretation of Landsat imagery at a scale of 1:1 000 000, generally agrees with the pattern identified on accompanying 1:250 000 scale maps (Figs. 7 and 8). We identified some

cultivated lands within the parcels mapped as uncultivated at the smaller scale, but these differences appear to be related to the difference between mapping scales.

In general, the remaining parcels of potentially arable, currently uncultivated lands identified in the Agricultural Land Base Study are relatively small in the areas near winter ranges. The largest parcels are found in the Milk River Ridge, Milk River and Lodge Creek ranges, and less than 25% of the areas of these ranges are classed as potentially arable. Given that these parcels are relatively small and isolated from developed agricultural areas, it does not appear that range conversion will create major pressure on antelope winter ranges in the near future.

Another possible means of expanding agricultural lands in the southern region of the province is through expansion of irrigation. The potential of the land to support irrigation is assessed on the basis of physiographic and soil profile features: Karkanis and Barton (1983) have produced a detailed map of irrigation potential in the southern region at a scale of 1:500 000.

A derivative of this map at a larger scale (Fig. 8) shows the reason behind the large proportion of cultivated lands and recent increases in these lands in the Newell Lake and Murray Lake winter ranges. Both of these ranges are in currently irrigated areas and circular, pivot-irrigated fields are common in both areas.

The impact of irrigation expansion on the other winter ranges is likely to be highly variable. A substantial fraction of the South Saskatchewan, Red Deer Valley and Grand Forks ranges has been assessed as fair to good for irrigation. Smaller amounts of potentially irrigable land are found in the Walsh Flats and Milk River Ridge ranges. The remaining ranges (Milk River, Sage Creek, Lodge Creek, Suffield and Canal Creek) do not contain lands classified as suitable for irrigation.

The recent report Status of the Fish and Wildlife Resource in Alberta identified population and habitat goals for the provincial pronghorn population. The goal of population management is to maintain numbers between 10 000 and 18 000 animals while the goal for habitat is to maintain or enhance the present year-round habitat of about 15 000 square km and winter habitat of 3 037 square km.

The results of this analysis indicate that there has been a considerable amount of land converted from native vegetation cover to intensive agricultural use over the past 15-20 years. Most of this conversion; however, has been in areas that would probably be classed as summer range. Agricultural expansion thus may not have had a great impact on the ability to maintain the provincial pronghorn population, because of the management emphasis on winter habitat.

The observed expansion of agriculture into known winter ranges is probably more significant from the standpoint of population management. At present, expansion has been confined mainly to the Lake Newell and Murray Lake winter ranges where irrigation systems have been

created, but there is potential for expanding into other areas as well.

On a regional basis, development pressures are likely to be least in the extreme southeast corner of the province where the Milk River, Sage Creek and Lodge Creek winter ranges are found and where the potential for agricultural expansion is regarded as low. Other winter ranges may come under greater development pressure, however. The recent changes in land use documented in this report coupled with assessments of land potential for further development provide a basis for projections of future habitat availability on which the maintenance of the provincial pronghorn population depends.

REFERENCES

Alberta Energy and Natural Resources, Fish and Wildlife Division. 1984. Status of the Fish and Wildlife Resource in Alberta. Alberta Energy and Natural Resources, Edmonton.

Alberta Economic Development. 1982. Alberta Industry and Resources. Alberta Economic Development, Edmonton.

Anderson, R.M. 1924. The present status and future prospects of the larger mammals of Canada. Scot. Geog. Mag. November, 1984, pp. 321-331. (cited in Mitchell 1980).

Barrett, M.W. 1982. Distribution, behavior and mortality of Pronghorns during a severe winter in Alberta. J. Wild. Manage. 46: 991-1002.

_____. 1984. Movements, habitat use and predation of pronghorn fawns in Alberta. J. Wild. Manage. 48: 542-550.

Barrett, M.W. and H. Vriend. 1980. Management implications of the seasonal distributions of pronghorns and land use practices in Alberta. Proc. Bienn. Pronghorn Antelope Workshop. 9: 196-214.

Birch, A. 1982. An inventory of changes in Alberta's agricultural land base between 1976 and 1980. Project Report RE-03-13-82, Resource Economics Branch, Alberta Agriculture, Edmonton.

Environment Council of Alberta. 1984. Maintaining and expanding the agricultural land base in Alberta: Summary report and recommendations. Environment Council of Alberta, Edmonton.

McCuaig, J.D. and E.W. Manning. 1982. Agricutural land use change in Canada: process and consequences. Land Use in Canada Ser. No. 21, Lands Directorate, Environment Canada, Ottawa.

MacGregor, J.G. 1972. A History of Alberta. Hurtig, Edmonton.

Mitchell, G.J. 1980. The Pronghorn Antelope in Alberta. Department of Biology, Univ. of Saskatchewan, Saskatoon, Saskatchewan.

Mitchell, G.J. and S. Smoliak. 1971. Pronghorn antelope range characteristics and food habitats in Alberta. J. Wild. Manage. 35: 238-250.

Nelson, E.W. 1925. Status of the pronghorn antelope, 1922-1924. U.S. Dept. Agr. Rept. No. 1346. Washington, D.C. (cited in Mitchell 1980).

Pearce, C.M., F. Ahern, R. Brown, K. Thomson, S. Klumph and C. Bricker. 1983. Monitoring rangelands in the mixedgrass prairies of southern Alberta with rangeland-enhanced Landsat imagery: a user's guide. Publ. No. 83-2. Alberta Remote Sensing Centre, Alberta Environment, Edmonton.

Plitz, P.J. 1982. A non-sophisticated, low cost approach for routing high voltage transmission lines using Landsat imagery. pp. 437-447. In Johannsen, C.J. and J.L. Sanders, eds. Remote Sensing for Resource Management. Soil Conservation Society of America, Ankeny, Iowa.

Seton, E.T. 1953. Lives of Game Animals, Vol. 3 Part 2, Order Ungulate or hoofed animals: deer, antelope, sheep, cattle and peccary. Charles T. Brantford Co., Boston (cited in Mitchell 1980).

Strong, W.L and K.R. Leggat. 1981. Ecoregions of Alberta. Tech. Rept. No. T/4, Alberta Energy and Natural Resources, Edmonton.

MAPS NOT

FILMED

CARTES

OMISES